STATE OF ILLINOIS
ADLAI E. STEVENSON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
NOBLE J. PUFFER, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, *Chief*
URBANA

CIRCULAR NO. 172

MINERAL RESOURCE RESEARCH AND ACTIVITIES OF THE STATE GEOLOGICAL SURVEY, 1949-1950

BY

M. M. LEIGHTON, *Chief*

Reprinted from the Annual Report of the Chief to the Director,
Department of Registration and Education,
for Fiscal Year 1949-1950

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS
1951

Dr. M. M. Leighton

ILLINOIS STATE GEOLOGICAL SURVEY

M. M. Leighton, Chief

The national prestige of any state is determined largely by two basic factors—its natural resources and the calibre of its leaders and of its citizenry. Illinois is singularly fortunate in both respects. Most of its prairie acreage is covered with fertile soils which yield rich crops. Beneath this highly productive surface lie mineral deposits of great value. Its geographic position in the heart of the upper Mississippi valley area, bounded by navigable rivers and touching on the Great Lakes, and its web of railroads and highways, give it ready access to market areas near and far. An enlightened and industrious citizenry under able leadership in government, industry, and science has, through proper exploitation and conservation of this natural endowment, brought Illinois to a position of eminence in the national picture.

Illinois ranks sixth among the 48 states in value of minerals produced, third in value of manufactured products, and fourth in value of agricultural production.

The value of mineral production in Illinois in 1949, amounting to nearly half a billion dollars, is given in the following table:

Coal	$192,901,000
Oil and Gas	189,818,000
Limestone and Dolomite	23,680,183
Cement	17,340,782
Clays and Clay Products	38,076,011
Fluorspar	4,621,733
Silica Sand	4,138,336
Other Sand	4,919,175
Gravel	5,468,026
Lead, Zinc, Silver	5,714,151
Other Minerals	1,887,145
	$498,564,542

Products of Illinois mines constituted 48.6 percent of the revenue freight originating in the State in 1949. The remaining 51.4 percent consisted of: Manufactures and miscellaneous, 32.2 percent; agricultural products, 15.7 percent; animals and animal products, 3.1 percent; and forest products, 0.5 percent.

The development and dissemination of basic information on the mineral resources of Illinois leading to the discovery of additional mineral deposits and of new or improved uses for mineral materials has been the primary objective of the Illinois State Geological Survey since its organization in 1905. These forty-five years have seen great changes in our way of life resulting from new concepts and inventions and the Geological Survey has kept pace with developments in research and technology in order to meet the demands of our modern industrialized society.

This growth with the times in the value of scientific research is exemplified in the excellent facilities which far-sighted legislation has made possible on the construction in 1939-40 of the Natural Resources Building on the University of Illinois campus in Urbana where the Geological Survey and the Natural History Survey are housed. New wings, completed with the current year, have afforded to both Surveys much needed additional space. In this fine building (see Figure 1) the Geological Survey has 40 laboratories equipped with the most modern scientific apparatus for geological, chemical, and physical research; x-ray and spectrography; and photography; as well as administrative and research offices. A separate building (see Figure 2) provides facilities for large-scale experimental work on the commercial feasibility of processes developed in the Survey's laboratories.

The Survey's research staff includes 46 geologists, 18 chemists, six engineers, editors, librarians, and draftsmen, and more than 20 college-trained research and technical assistants. Its internal organization as well as its cooperative relationships with other State and Federal agencies is illustrated diagrammatically in Figure 3.

Financial Statement

The following is a statement of funds available and expenditures for the fiscal year beginning July 1, 1949 and ending June 30, 1950:

Appropriation Item	Allotment 1st Year	Expenditures to June 30, 1950	Encumbrances	Free Balance
Personal Services, Regular	$523,190	$502,565	....	$20,625
Personal Services, Extra Help	14,260	13,656	....	604
Contractual Services	12,730	10,634	$ 223	1,873
Travel	18,060	17,297	....	763
Office Expenses	1,200	1,292	....	—92
Commodities	31,650	31,133	2,709	—2,192
Equipment	25,000	16,399	648	7,953
Topographic Surveys	31,250	29,536	1,589	125
Employment Contribution to University Retirement System of Illinois	14,113	14,113	....	.....
	$671,453	$636,625	$5,169	$29,659
Printing	27,500	21,666	3,481	2,353
Postage	2,712	2,712	....	.....

The expenditures through June 30, 1950, were distributed among the following activities:

Coal	$117,302
Oil and Gas	48,800
Industrial Minerals	53,013
Clay Resources and Clay Mineral Technology	18,283
Fluorspar	9,809
Ground-Water Geology and Geophysical Exploration	34,882
Engineering Geology and Topographic Mapping	36,458
Subsurface Geology	35,715
Areal Geology and Paleontology	14,318
Geological Resources Administration	14,675
Mineral Economics	16,516
Physics	9,533
Geochemical Administration, etc	20,975
X-ray	6,705
Analytical	21,908
Educational Extension	11,477
Mineral Resource Records	20,088
Publications	25,051
Public Service (clerical, information office, mail distribution)	27,999
General Administration (Chief's office, financial records, motor cars, library, photography, retirement, etc.)	93,118
	$636,625

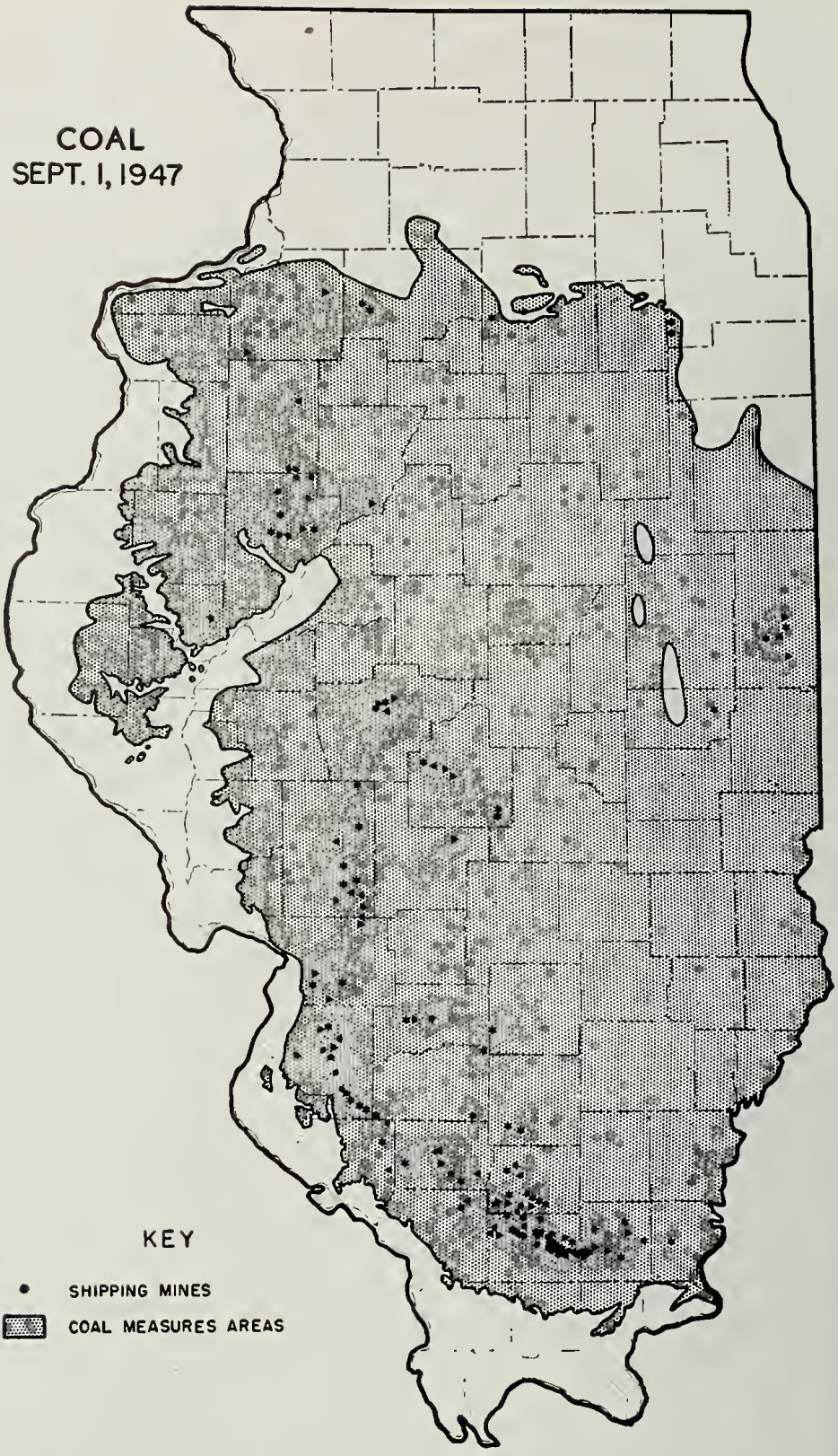
Permanent Improvement

Special Funds to Geological and Natural History Surveys

	Appropriation	Expenditures to June 30, 1950	Balance
Additions to Natural Resources Building at Urbana-Champaign, with fixed equipment installed—SB 680	$ 86,124	$ 5,841	$ 80,283
Additions to Natural Resources Building at Urbana-Champaign, with fixed equipment installed—Reapprop. SB 655	762,614	448,758	313,856
Purchase and install fixed equipment, scientific apparatus and furniture for new wings of Natural Resources Building—SB 680	555,000	1,044	553,956

Coal

Illinois produced nearly 48 million tons of coal in 1949, an amount exceeded by only three other states—West Virginia, Pennsylvania, and Kentucky.



More than half of Illinois is underlain by the Coal Measures. Dots show locations of shipping coal mines as of 1947.

Strip-mining coal in Fulton County, Illinois.

The Geological Survey's research on coal has attracted the attention of other research agencies in our own country and abroad. During the past year visitors to the Survey's coal laboratories have included representatives from government or research agencies, from many other states in this country, as well as from Mexico, France, and England. In addition, members of the Survey staff have participated in various scientific and technical meetings, contributed original papers, and otherwise added to human knowledge.

1) *To find more coal* of competing quality is a natural objective of the operators whose present holdings are reaching their productive limits. The State Geological Survey performs a valuable service to the industry and the State in assisting in this search by studying and interpreting cuttings and cores from test drilling and by furnishing accurate information from its technical files. In the course of exploratory drilling carried on in Edgar, Montgomery, Williamson, Jefferson, Randolph, Livingston, Woodford, Cumberland, and Saline counties, and in the Eagle Valley region, Survey geologists logged over 23,000 feet of core from 86 diamond drill holes. Some new mines have been or are being opened in northern Montgomery County, at Waltonville in Jefferson County, in Madison County, south of Royalton in Franklin County, and at other points.

2) *Comprehensive study of coal resources* of the State is one of the major activities of the Survey's Coal Division. This past year has seen the completion of a report on Marion County and parts of adjacent counties. Structure maps of the coal measures were made for Vermilion, Wabash, and White counties, and reports on these counties are nearing completion. Upon completion of a study now in progress on the structure and coal resources of Effingham, Moultrie, and Shelby counties, all of the counties in the Illinois Basin will have been mapped with the exception of Coles and Cumberland counties which will be studied in the near future.

The structure maps which are one of the results of this work are of great value not only to the coal industry but to individuals and operators interested in the development of oil and gas, for the structure of coal measures strata frequently indicates the presence at greater depth of structures favorable to the accumulation of oil and gas.

3) *Areas of strippable coal* are delineated by the Survey to assist the industry in locating additional resources of this type. During the course of the Survey's work in the past year, coal outcrops were studied in Jefferson, Shelby, and Wayne counties to determine possibilities for strip mining, and commercial operations have been undertaken at several places.

4) *A reappraisal of Illinois coal reserves* minable under present conditions was begun in April 1950 at the request of the National Bituminous Coal Advisory Committee of the Federal Government. Because of the importance to the national welfare of this critical information, this work is receiving primary attention in order that it may be completed at the earliest possible date.

5) *Millions of tons of Illinois coal* have found their way to a new market since the Geological Survey began its research on the use of Illinois coal in the manufacture of metallurgical coke. Originally sponsored by the War Production Board, the initial aim of materially reducing long freight haul of eastern coal to coke plants in the Middle West and releasing rolling stock for other critical purposes was soon achieved, and for the past several years more than one million tons of Illinois coal have been used annually by the steel industry of the Chicago and St. Louis areas in the manufacture of metallurgical coke.

An experimental coking oven of 500 pounds coal capacity, designed and built by members of the Survey staff, satisfactorily served as a pilot installation for determining what coals are suitable and economical for trial by large commercial ovens. The efficiency of this small unit for experimental work has prompted research organizations from many foreign countries to request blueprint plans from the Survey, and several similar ovens are now in operation at various places in this country and elsewhere. A by-product recovery train makes possible the collection and evaluation of tar and gas products.

During the past year, the Survey has continued to consult frequently with large steel companies and coking plants on coking problems, and a producer in Minnesota has recently started to use about 100 tons of Illinois coal per day for making blast furnace fuel.

6) *The experimental preparation of char from Illinois coals* for use as a substitute for low volatile coal in metallurgical coke blends is a companion project to the coal blending studies described above. Pilot plant equipment has been designed and built, and its operation during the past year has been initially successful in indicating that there is promise of converting Illinois coal into char of desired volatile content.

Cokes have been produced from both the No. 5 and No. 6 seam coals blended with char which have all the appearances of satisfactory blast furnace fuel and compare favorably with coke made from blends of high and low volatile coals. Other phases of the problem are now under exploratory study. These studies will be extended to correlate operating procedures with char properties and to test various Illinois coals.

7) *Improved stoker fuel* has been the objective of a long-range program in the Survey's applied research laboratory. Carefully controlled investigations have demonstrated the relationships between the combustion characteristics of coal and its chemical and physical composition as well as the effect of coal size upon combustion characteristics. The combined efforts of Bituminous Coal Research, the Stoker Manufacturers Association, and the Illinois Survey, have resulted in the design and erection at the Survey's laboratory of a trial standard stoker boiler set-up in an attempt to develop a standard method of testing stoker coals.

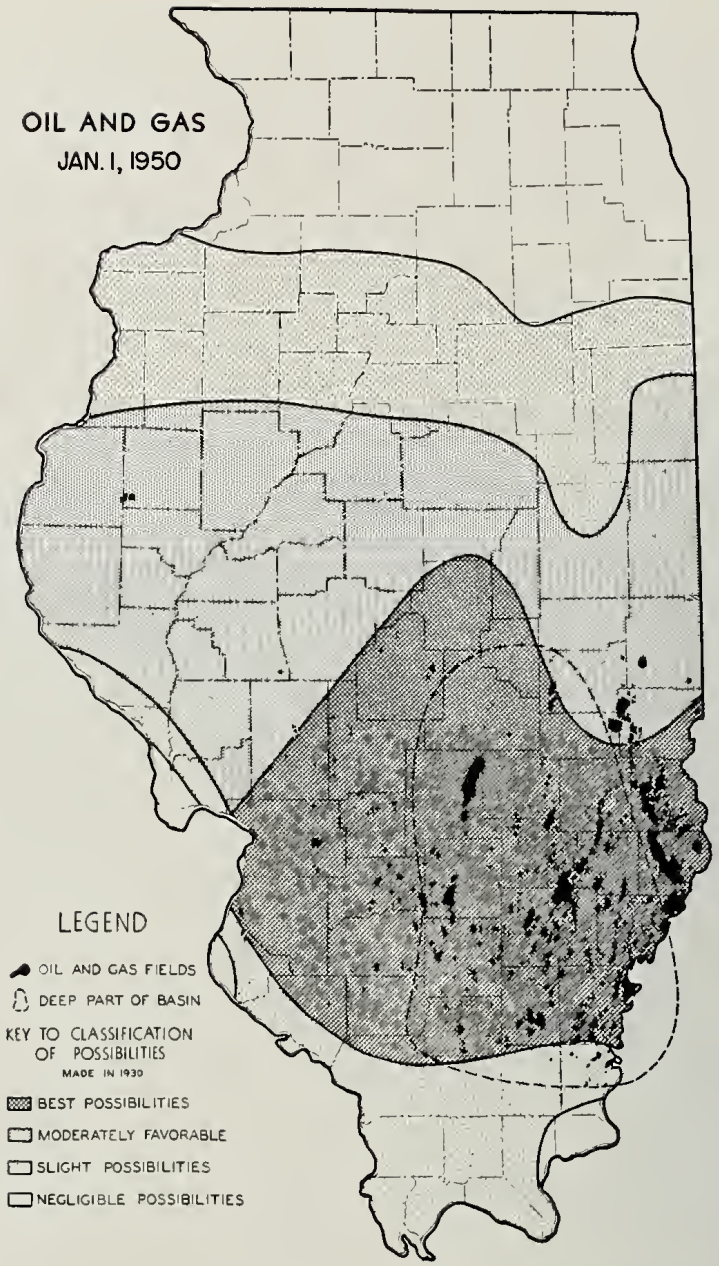
A report, completed during the past year, shows that stoker coals from Illinois have properties which place them in an excellent competitive position.

8) *Sampling and analysis* of coal for State institutions has been undertaken in the Survey laboratories at the request of the Division of Purchases and Supplies of the State Department of Finance. During the year covered by this report approximately 150 coal samples have been received by the Survey under this program.

9) *Fossil plant material* from Illinois coal, identified through the microscope by special laboratory techniques, has proved a valuable tool in correlating various coal beds. Survey Bulletin No. 74 entitled, "Pennsylvanian Spores of Illinois and Their Use in Correlation", is a comprehensive report on these studies and of great value to students of coal measures strata everywhere.

"Coal balls", first discovered and described in America from Illinois coals by the late Dr. A. C. Noé, the Survey's noted paleobotanist, and which are singularly rich in well-preserved fossil plants, are yielding valuable scientific information on the subject of what types of plants compose and help determine the properties of various coals.

10) *New light on the chemical and physical nature of coal* is being gained from continuing fundamental studies in the Survey's laboratories directed toward the extended use of coal as a chemical raw material and the improvement of present methods of storage, preparation, and use.



Map classifying oil and gas possibilities in Illinois, showing producing areas as of January 1, 1950. (Classification of areas made in 1930 by Alfred H. Bell.)

Oil and Gas

Illinois produced nearly 65 million barrels of oil during the 12 months ending June 30, 1950, and continued to hold sixth place among the oil producing states of the nation. It is remarkable that daily average production has remained fairly constant in Illinois for the past three years. This is a striking demonstration of the fact that the natural decline in production from "old" wells continues to be offset by the discovery of new small pools, extensions to old pools, new "pay sands" in old pools, and water flooding, and is, in itself, a fine tribute to the

aggressive resourcefulness and perseverence of the oil industry. From July 1, 1949 through June 30, 1950, 28 new pools, 79 extensions, and 29 new "pay sands" in pools were discovered. Outstanding developments of the past year within previously discovered pools have been the development of the Assumption North pool in Christian County, the expansion of the area of Trenton production at the north end of the Centralia pool (to such an extent that about half of the oil now being produced in the pool comes from the Trenton), and an eastward extension of the Louden pool with over 100 wells already completed.

11) *Assisting the search for new oil* is a major activity of the Geological Survey's Oil and Gas Division. Through the scientific interpretation of well records, the microscopic examination of drill cuttings, and the preparation of special maps and reports, the Survey guides operators in their search for new oil pools and assists land owners in evaluating their properties.

12) *Large-scale structure maps* of various areas in and around the Illinois Basin have been prepared and are continually being revised as new drilling information is received. Such maps are invaluable in answering the many requests for information relating to oil and gas.

13) *Geologic study of oil-producing zones* is continually in progress to increase existing knowledge of their physical characteristics, their position in the geologic succession of strata, and their relationships. Any given geologic condition varies from place to place, and a better understanding of this variation is essential to accurate correlation of critical geologic horizons and the search for potential "oil sands". Such "facies" studies are receiving increasingly critical attention of oil geologists everywhere.

During the past year intensive study was made of the very productive lower Chester and Ste. Genevieve beds, particularly the Aux Vases sandstone, and a special study of the Waltersburg sandstone was extended from the area where it is productive into Wayne, Hamilton, and Richland counties in which this particular formation is not productive. A report on the Waltersburg sandstone pools of the lower Wabash Valley was presented by a member of the Survey staff at the Annual Meeting of the American Association of Petroleum Geologists in 1949.

14) *The secondary recovery of oil* has been the subject of continued study by the Survey's Petroleum Engineering Division. Gradual decline in production by pumping of the older wells toward their economic limit necessitates either abandonment or the adoption of some secondary recovery method. The water flooding method whereby a substantial part of the oil remaining in a "sand" after natural flow and pump production have waned, is flushed out of the reservoir rock by water pumped into the sand through an input well, was introduced in Illinois in 1943 largely as a result of Geological Survey studies. The relative importance of this method of recovery has progressively increased until now oil recovered by water flooding amounts to approximately five percent of the total production of the State.

A report containing information on current developments in water flooding operations and detailed studies of the geologic and engineering factors of specific water flood projects has been prepared for publication.

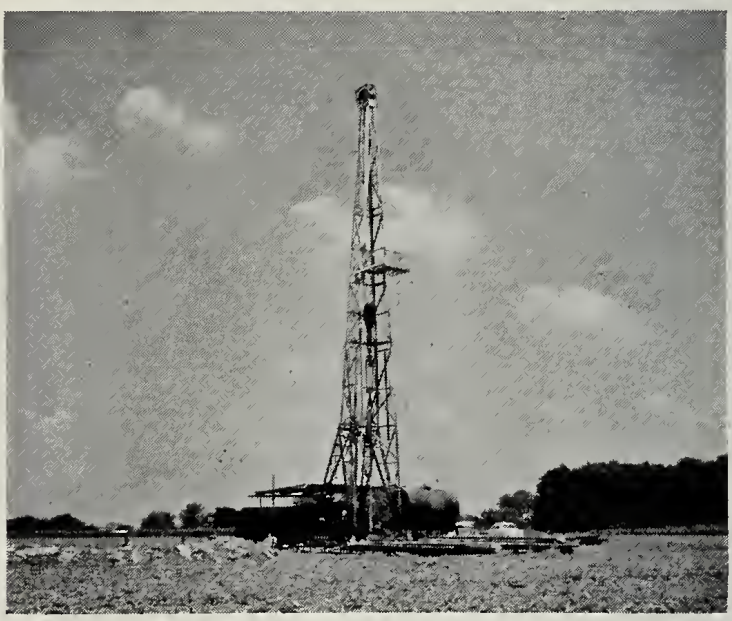
Members of the Survey staff have been engaged also in directing the work of the Secondary Recovery Study Committee for Illinois, appointed by Governor Stevenson's representative on the Interstate Oil Compact Commission. A report is being prepared which will be issued simultaneously as a report by the Interstate Oil Compact Commission and by the Survey.

15) *Field engineering work* has been continued on the measurement of gas-oil ratios and has been expanded as a result of requests both by operators in certain areas and by the American Gas Association to establish more authentic data on gas recovery from Illinois oil wells.

16) *Monthly drilling reports,* tabulating drilling activity throughout the State, are issued. Data for this report are received through the Illinois Basin Scout Association of which the Survey's oil scout is a member. The Survey scout is responsible to the Association for a weekly report on all drilling activity within a district which includes approximately the northern half of the State. Greatly increased activity in this district during the past year has added appreciably to his work.

Forty-seven development maps of oil producing areas, each three townships square, and showing the results of drilling operations, are revised at three-month intervals and are available from the Survey at nominal cost.

17) *An annual report on oil and gas production* in Illinois in 1949 was prepared. Such annual reports have been made without interruption since 1936 and constitute, for prospectors and others, a very complete record of oil well drilling and pool discoveries in the State over that period.



"Wildcatting" for oil in Illinois.

18) *Information service* on oil and gas resources and development continues to increase. During the past year, more than 750 individual conferences were sought by members of the industry and general public who wished information or advice regarding the occurrence of oil and gas in the State. In addition, more than 1,200 letters were sent out by the Survey in response to requests for information, and there was a constant flow of loan copies of driller's logs from the Survey's files.

A striking illustration of the value of these conferences to the State is that of an oil company whose representatives visited the Survey offices some two or three years ago collecting data on the northern edge of the main productive area in the State. This company's decision, made at that time, to enter upon an extensive exploration program at the northern edge of the basin, resulted in the discovery, a little over a year ago, of Assumption North, the largest pool found in the State in recent years; the more recent discovery of Elbridge, an important reef pool in the eastern part of the State, which opens a considerable area in Edgar and Vermilion counties to further exploration; and the very recent discovery at Plainville, Indiana, near the State boundary.

Clays and Clay Products

Though not commonly thought of as particularly valuable materials, clays and clay products produced in Illinois in 1949 were valued at more than 38 million dollars. Structural clay products (common, face, and paving brick; drain, structural, and ornamental tile, etc.) had a value in 1949 of $15,077,840; refractories, $7,622,047; and whiteware and pottery, $14,381,373. Approximately 8 percent of the brick output of the nation is produced in Illinois.

19) *Valuable assistance* to the clay industry results from fundamental research carried on in the Survey's laboratories. Mineralogic and x-ray studies have revealed that clays are commonly made up of a variety of clay minerals, the predominance of any one exerting a strong influence on the properties of the clay. Laboratory investigations of the behavior of certain clay mineral components of a raw clay at elevated temperatures or of the effect upon the clay of additions of small amounts of certain chemicals have developed a large amount of basic information of great importance to the clay industry in solving many processing problems.

Data obtained from one such line of investigation enabled a large clay operator to reduce the time required to fire his brick by about 25 percent. Another special study demonstrated that a particular clay from southern Illinois, recently forced out of its competitive market as a decolorizing agent, probably has important potential value as a bonding material. Thus a local industry may be rescued. Another brick company in the State made a pilot plant test run of a process suggested by the Survey to develop a light-weight brick and results were sufficiently promising so that the company is planning to make a full-scale plant run.

It is apparent from the foregoing that the Survey is correlating the results of its fundamental research with the practical problems of industry.

20) *Complete inventory of clay and shale resources* of the State is the goal of another long-range project of the Survey. Field investiga-

tion and sampling of deposits and laboratory analyses of clays continue to increase the wealth of information in the Survey's files, and enable the Survey to guide operators and manufacturers to deposits of clay having the special properties needed to meet industrial specifications.

During the year, the mineral composition and properties of approximately 40 samples of clay from various parts of the State were determined. Particular emphasis is being placed on a study of the resources and properties of high-grade clays in Calhoun, Fulton, Scott, Morgan, and Pike counties. This area contains some high-grade ceramic clays which have supported a considerable industry, but additional deposits are necessary in the immediate future to maintain the industry. Also, the structural clay products industry elsewhere in the State is interested in obtaining a supply of light-burning clay from this area for making face brick. The study of the field occurrence has been accomplished, laboratory testing of the samples is about 75 percent completed, and a report is in progress.

21) *The oil industry is particularly interested* in certain aspects of the Survey's clay research. Since some clays swell when wet, the success or failure of a water flooding operation for secondary recovery of oil may rest upon the kind of clay which may be present in small amounts in a given oil sand. As a service to the oil industry, the Survey makes determinations of the clay mineral composition of oil sands in cores submitted by the industry. During the year, 15 such analyses were made.

Hydraulic mining in a large Illinois glass sand quarry.

22) *Data vital to construction projects* are being developed in the Survey's clay laboratories. Engineering structures are frequently built on, through, or with clay materials, and the construction engineer must be able to predict how the particular soil will act in the course of time under the conditions of load and drainage which are superimposed on it. To make such predictions safely, it is essential to understand the factors that determine variable compaction, susceptibility to shear, and other soil mechanics properties of clays. Soil materials, known by engineering experience to have unusual properties, are being analyzed to reveal the factors causing the unusual properties and to extend our understanding of soil mechanics. To date, about 40 such soil samples, some of them from foreign countries, have been analyzed in the Survey laboratories.

23) *The prestige of the Survey's laboratories* throughout the world is evidenced by the continuing visits of clay research workers from foreign countries. During the past year, visitors have come to the Survey laboratories from South Africa, the Philippines, Australia, New Zealand, Argentina, Holland, Israel, and Brazil—eloquent testimony to the outstanding research being carried on in Illinois.

Rock and Rock Products

The combined value of rock and rock products, sand and gravel produced from more than 400 quarries in Illinois in 1949, amounts to more than 55 million dollars.

24) *Industry's location of new quarry sites* is aided by the State Geological Survey. Only in the Survey's files can be found the detailed analytical information necessary to the location of deposits possessed of properties which will meet industrial specifications for particular uses, and operator and land owner alike benefit from this service. Data assembled and made public by the Industrial Minerals Division of the Survey stimulated interest in the possibilities for limestone quarries in southeastern Christian County. Early in 1950, test drilling, based on Survey data, by a quarry operator desirious of locating in this area, revealed a suitable deposit of stone which will soon be developed commercially. Because of the favorable market situation of southeastern Christian County and the probable presence of other workable limestone deposits, the development of other quarries seems likely.

Similar studies by the Survey of the Marigold member of the Okaw formation in Randolph County and of the Kincaid and Menard formations in eastern Johnson, western Pope, and northern Massac counties, indicate potentialities for commercial development in these areas.

25) *More agricultural limestone is used in Illinois* than in any other State in the country, and the Survey gives special attention to resources of limestone suitable for agricultural use. Samples submitted by land owners are analyzed by the Survey free of charge.

26) *High-purity limestone resources of Illinois* is the subject of a brief report accompanied by a map and table of chemical analyses prepared by the Survey. This report is consulted for information on high-purity limestone resources and their accessibility for commercial

development. These resources occur chiefly along the Mississippi River, lower Illinois River, and in the extreme southern part of Illinois.

27) *Fundamental research on Illinois limestones and dolomites* is in progress to develop comprehensive information on the mineralogy, lithology, composition, and properties of various limestones and dolomites, in order to develop a better knowledge of these rocks and to extend their use.

28) *Sand and gravel resources of Illinois* continue to receive study in order that the Survey may assist operators, construction engineers, and foundries in their search for deposits which will yield materials adapted to their particular needs.

29) *The State's silica resources* have been the subject of investigation in the Survey's laboratories to increase basic information not previously available to the industry. During the past year two special reports were prepared, one on the "ground quartz" silica produced in northern Illinois, and one on the "soft" or microcrystalline silica of southern Illinois, and were furnished to producers in both areas.

30) *Special chemical studies of silicate melts* are in progress in the Survey's laboratories to develop information on viscosity and surface tension of industrial slags required to meet industrial problems in the manufacture of glass, porcelain, mineral wool, and other ceramic products, or in metallurgical processes.

The Natural Resources Building, on the University of Illinois campus in Urbana, houses the State Geological Survey and the State Natural History Survey. The central unit of the structure was built in 1940 and wings added to east and west ends were first occupied in the spring of 1950.

Fluorspar

More than half of the nation's entire production of fluorspar in 1949 came from Southern Illinois. Used principally as a flux in the steel industry, an increasing and more valuable fraction of fluorspar produced is finding its way to other markets, chiefly those of the highly diversified chemical industry where it is in growing demand for use in refrigerants and other fluorine compounds, for enamels, glasses, etc.

31) *Additional deposits* of this critical mineral must be found if its production is to keep pace with demand. Intensive field work in the area and ensuing investigations in the laboratory enable Survey geologists to assist operators and land owners in locating new veins or extending present mining operations. During the past year interpretation by a Survey geologist of the local geological conditions prior to a test drilling program led to the discovery of a promising new fluorspar deposit northwest of Rosiclare in Pope County.

Laboratory investigations, directed toward a more complete understanding of the conditions under which fluorspar deposits were laid down, as well as special studies of the weathered trace of fluorspar veins are in progress and should lead toward improved techniques in interpretation of field data and location of new deposits.

32) *Outstanding chemical research on fluorine* is being carried on in the Survey's laboratories and should result in more diversified use of Illinois spar as a chemical raw material. Requests received by the Survey's fluorine laboratory for samples of organic fluorine compounds indicate an increasing interest in this research in medical, pharmacological, insecticidal, and fungicidal fields.

One of the interesting results of the Survey's cooperative research contract with the Office of Naval Research has been the awarding of a substantial research contract by the U. S. Air Corps to a member of the Illinois State Natural History Survey staff for a fungicidal and toxicity study of organic fluorine compounds prepared in the Geological Survey laboratories. The Geological Survey has also furnished special samples of organic fluorine compounds for experimental purposes to five medical research centers.

Zinc and Lead

The renewed activity in the old zinc and lead producing region of northwestern Illinois in recent years is largely the result of the State Geological Survey's field investigations in this area, begun in 1943 under the impetus of war-time need for these important minerals. The Survey's findings encouraged mining companies and prospectors to re-enter the area, and millions of tons of additional zinc ore have been discovered.

33) *From the Survey's field office in Galena* two of its geologists are continuing intensive field investigation and cooperating with operators and prospectors by laboratory examination of samples and by making known geologic conditions.

34) *New structure maps* showing several recently discovered synclines which appear favorable for prospecting were completed during the year and were placed on open file in the Survey's field office in Galena,

as well as in the main office in Urbana. Thus new critical information derived from the Survey's work is made promptly available to the industry, stimulates prospecting, and leads to increased production. Much of the prospecting for ore deposits in the district has been guided by the Survey's geologic studies.

35) *Geophysical prospecting in northwestern Illinois* has been carried on by the Survey during the summer of 1949 to discover the practicability of such methods in the exploration for ore bodies. Data so far secured indicate that such methods hold considerable promise.

Entrance to new zinc mine in northwestern Illinois.

Groundwater Resources

The vital importance of water to every individual, community, a industry is apparent. The full time service of seven highly trained me bers of the Geological Survey staff, as well as part-time service of otl staff members is devoted to the various geologic factors governi groundwater supplies.

36) *Special reports* are prepared on the geology of specific lo tions where water is needed. These reports tell the driller or land ow what kind of rocks underlie his land, in which of them water is likely occur, and at what depths it will be found. During the past year 247 s reports were prepared, of which 51 were for municipalities, 25 for pu

institutions, 43 for industrial companies, and 111 for private citizens, and 17 geophysical reports, chiefly for municipalities.

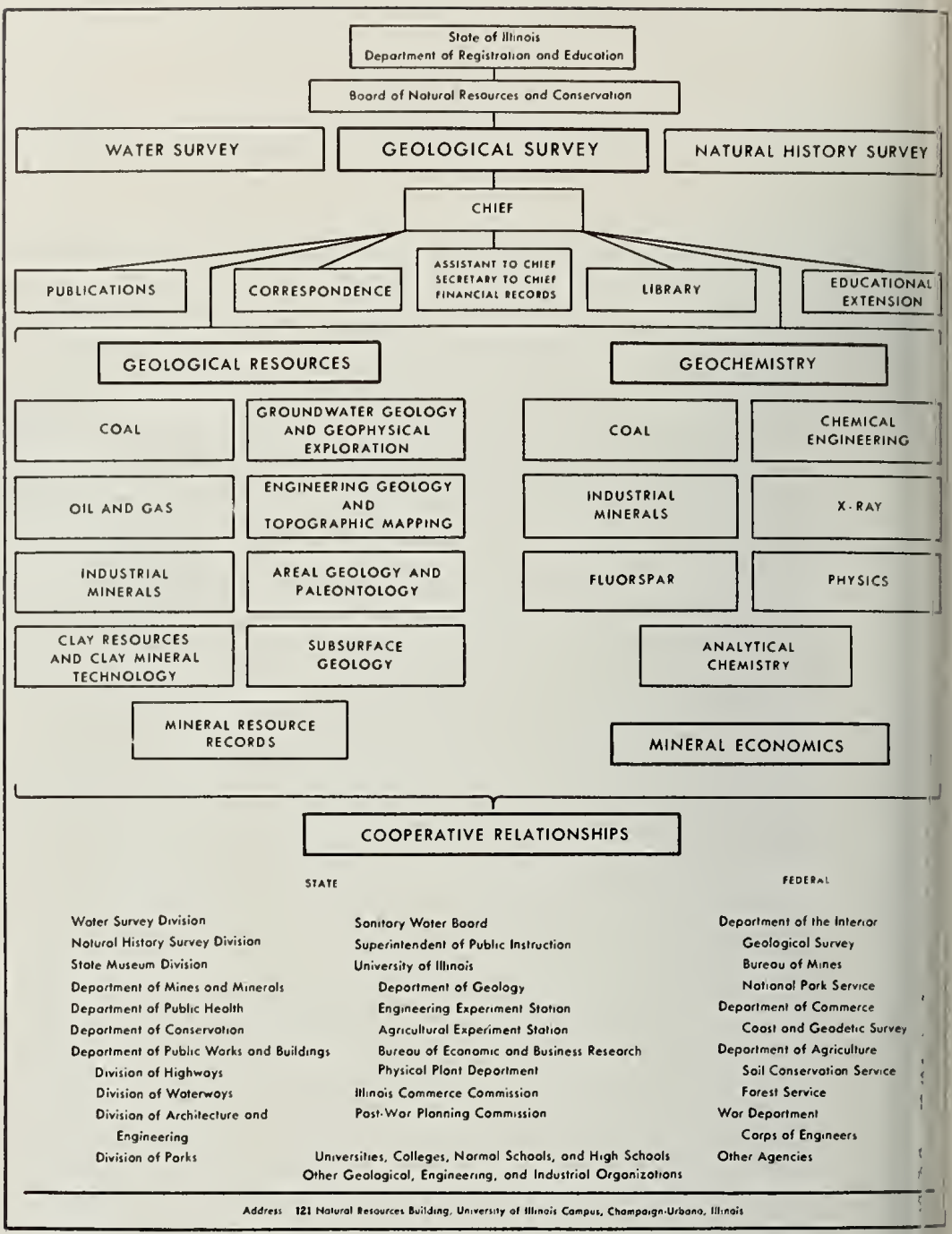
A comprehensive report on groundwater in the Peoria region prepared jointly with the State Water Survey was completed and made ready for printing.

37) *Assistance in developing data from test drilling* is rendered by Survey geologists through the study and correlation of samples and through making and reporting on mechanical analyses of them.

38) *Water-bearing sands and gravels* from which large yields may be expected can generally be located to a depth of 200 feet by earth resistivity measurements. This scientific technique of using an electric current to determine the presence and depth of subsurface water resources was initiated in Illinois by the Geological Survey nearly 20 years ago and has met with outstanding success. Such surveys are made without charge, the only requirement of the municipality or industry so served being to furnish four helpers for the routine field work. During the past year, 21 such surveys have been run. Because the work can only be done when the weather is open, and because this type of assistance is greatly in demand, the Survey's schedule for this service is always booked for months ahead.

39) *Cooperation with the Illinois Water Well Drillers Association* has been continued, a member of the Survey staff serving as Executive Secretary of the Association. This cooperative effort is extended to promote the science and art of water-supply development.

Survey geologists in an earth resistivity search for ground water supplies.



Organization chart.

Geophysical Research

40) *Geologic aspects of radio-wave transmission* has been the subject of study in the Survey's laboratories for several years. This highly specialized line of research was undertaken to investigate the propagation of radio waves through earth materials and to ascertain the possible applications of radio techniques to geological and geophysical problems. A summary report of results obtained to that date was published in February 1950 and aroused keen interest in such fields as the oil and gas industry, the U. S. Army Signal Corps, and major telephone and communications system. Additional research will be made.

Engineering Geology

Large engineering projects, such as those involving problems of highway construction, the selection of suitable sites for dams and reservoirs, and the stability of earth materials for foundations for large structures, almost invariably involve problems relating to the geologic conditions at the site of construction. The Survey's Engineering Geology Division cooperates with Federal and with other State agencies on problems of this type.

41) *Geologic assistance on engineering problems* is rendered through field and office conferences. Where necessary, earth materials are sampled and studied and reports are prepared. During the year, this type of cooperation was extended to the State Division of Highways in regard to a landslide near Edwardsville; to the State Department of Conservation in connection with test borings on a tributary of Second Creek near Effingham, and a tributary of King Creek near Kewanee, as well as on dam sites for proposed recreational lakes northeast of Urbana and north of Monmouth; to the State Department of Public Health with reference to pollution of Illinois River; to the U. S. Army Engineers regarding proposed harbor at Rock Island, and increased flood protection at Beardstown; to the 9th Naval District in regard to possible sites for shipyards along Mississippi and Illinois rivers; to the Peoria Airport regarding the subsidence of its apron over mined-out areas beneath it; to the University of Illinois regarding the proposed reservoir on the Allerton Estate; and to numerous individuals and organizations regarding various engineering problems.

Basic Scientific Studies

Basic research in geology, chemistry, and physics is continually in progress in order to develop the fundamental information essential to the solution of specific practical problems.

42) *Rock strata lying deep underground* can be studied mainly by the examination under the microscope of drill cuttings from deep wells. During the year, 22,000 samples from 445 wells, totalling a drilling distance of nearly 25 miles, were examined by the Survey's Subsurface Geology Division. From these studies comes information on the identity, character, and extent of rock formations, which is of inestimable value in the location of mineral deposits.

43) *Detailed study of certain rock formations,* both as they occur at the surface and as they are observed through the microscope, reveal correlations that are of far-reaching significance in many ways. Such detailed studies made by the Survey in recent years over an extensive area in northwestern Illinois have been successful in revealing the geology of large areas heretofore undifferentiated, in improving our knowledge of groundwater resources, in mapping limestones and dolomites suitable for many uses, in revealing key beds to guide in prospecting for lead and zinc, and in helping to solve many problems in engineering geology.

44) *Fossil accumulations of ancient animal and plant life* occurring in rock strata reveal to the scientist the conditions existing at the time the rocks were formed and constitute a valuable criterion in correlation of strata. A report published during the past year on fossil coral reefs in the Niagaran limestone of Silurian age in Illinois, for example, has been enthusiastically received by the oil industry and will serve as a valuable guide in the exploration for such reefs in some of which oil has been known to accumulate.

45) *Spectrographic analysis* of rock and mineral samples discloses the presence of and identifies trace amounts of mineral substances in earth materials. Such substances frequently have an important bearing on the properties and use of the materials in industry and agriculture. The Survey is adding to its spectrographic equipment to make possible the extension of these studies by the Survey's physicist.

New water well in Champaign-Urbana area located by the Illinois Geological Survey through the earth resistivity method. (Champaign-Urbana Courier photo.)

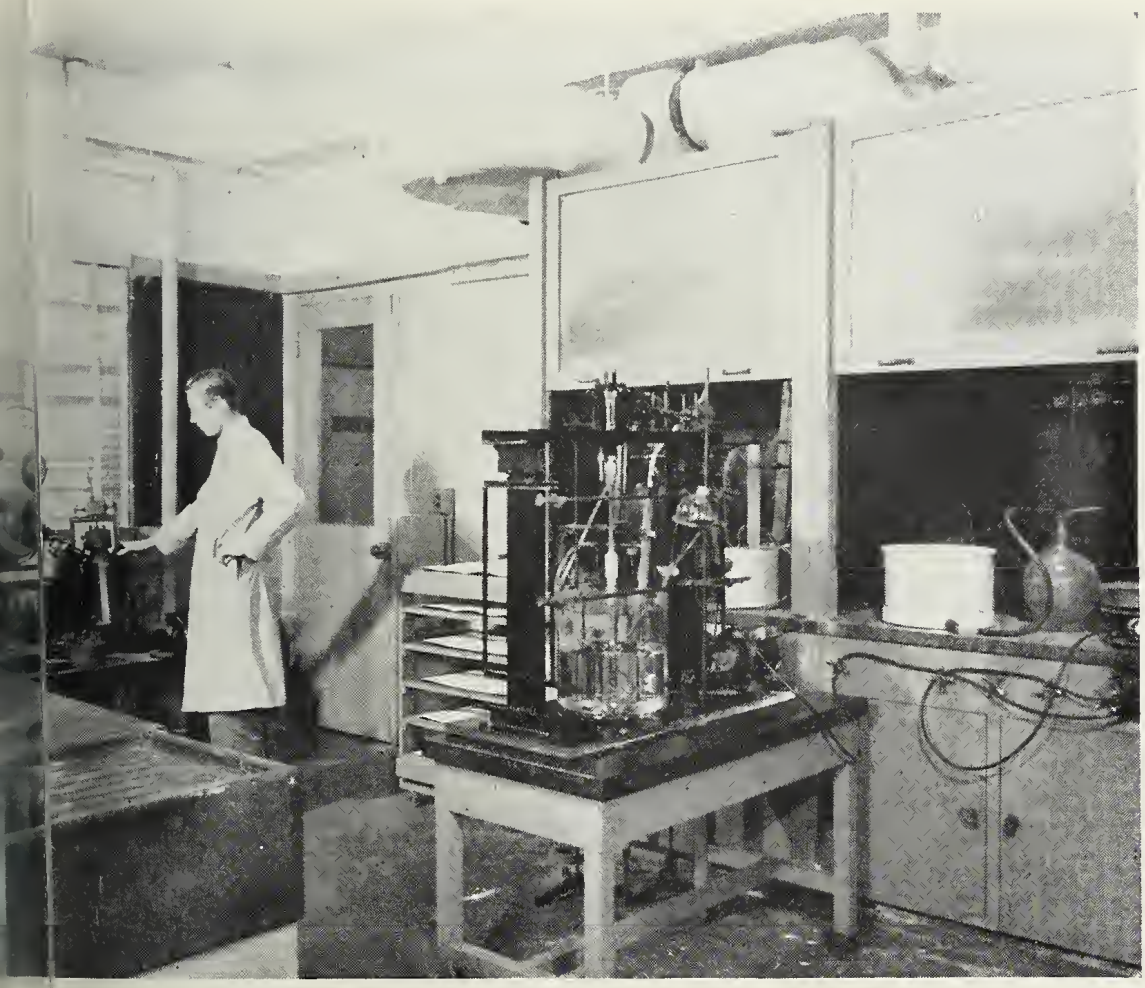
Mineral Economics

The economic trends and competitive elements in mineral production, transportation, and marketing are critical factors in industrial development. Through the employment of a mineral economist with a small staff of assistants to follow and analyze these problems, the Survey is in position to furnish economic information desired by mineral operators, producers, manufacturers, railroads, chambers of commerce and financial organizations throughout the State.

46) *The economic importance of the Illinois waterway* as a means of transporting fuel products was the subject of a special study completed during the year.

47) *The market for agricultural limestone* was carefully analyzed.

48) *A special economic analysis* is being made of the importance of minerals to the productive economy of the upper Mississippi Valley, the sources of these minerals and their significance in relation to agriculture, manufactures, construction, and transportation.



Laboratory for special research on fluorine and its compounds.
The Survey has many such fully equipped laboratories.

49) *The 1949 statistical report* on the Illinois mineral industry is being prepared for publication. This work is carried on in cooperation with the U. S. Bureau of Mines, the U. S. Bureau of the Census, and the State Department of Mines and Minerals. Similar annual reports issued since 1931 constitute an uninterrupted series on Illinois' mineral industry since that date.

Topographic Mapping

50) *A systematic program of mapping* the topography of the State is carried forward each year in cooperation with the U. S. Geological Survey. The ultimate goal is to cover the entire State. Through the progressive attitude of Illinois legislators in regularly appropriating funds to carry on this work, which funds are matched dollar for dollar by the Federal Government, our State is now nearly 90 per cent mapped. It is hoped that funds will be appropriated to complete the mapping of Illinois in the next few years.

During the past year 567 square miles of territory, including 328 square miles of revision, were mapped topographically in the field on a scale of one inch to a mile; 169 square miles including 3 square miles of revision were mapped on a scale of 2½ inches to the mile; 57 square miles of multiplex contouring were completed in the field; planimetric maps to serve as bases for contouring of 1,627 square miles were prepared.

Seventeen new quadrangle maps, on a scale of 1 inch to a mile, 1 new quadrangle maps on a scale of 2½ inches to a mile, and remaps of five quadrangles and reprints of 12 quadrangle maps on a scale of 1 inch to a mile were published as a result of this cooperative work.

Public Service and Educational Extension

51) *Public information.* Prompt and accurate response to all requests for information relating to mineral resources, their occurrence, distribution and development, is considered by the Survey one of its major obligations to the citizens of the State. Thousands of such requests are received and handled each year.

52) *Educational Extension.* For the past 20 years a special division of the Geological Survey has been rendering Educational Extension service throughout the State. Designed primarily to assist the teachers of the State, the activities of this Division include free identification of mineral specimens, informative correspondence with teachers, pupils, and individuals, free lectures to organized groups, the publication of popular educational pamphlets, the distribution of free rock and mineral collections to schools, the organization and leadership of field-study conferences for science teachers, and educational exhibits at State and county fairs and special scientific meetings.

During the past year, 485 sets of rock and mineral specimens were distributed to schools, scout troops, nature clubs, and other civic organizations throughout the State.

Field conferences, primarily for science teachers but open to all interested persons, were held in six different areas widely distributed over the State.

Fourteen special lectures were given to conservation work shops of colleges, high school assemblies, night school classes for veterans, local scientific societies and clubs.

Publications

Prompt publication of results obtained from research work is essential to its greatest effectiveness. Every effort is made by the Survey to furnish information to the citizens of the State as soon as possible consistent with accuracy.

53) *Publications issued during the year* include the following:

Bulletins

73. Bedrock Topography of Illinois: Leland Horberg. 1950. 111 pp., 23 figs., 2 pls.

Reports of Investigation

143. Petrographic Analysis of Coal by the Particle Count Method. Bryan C. Parks. (Reprint from Econ. Geol., vol. 44, pp. 376-424, 1949.) 49 pp., 14 figs.
144. Atterberg Plastic Limits of Clay Minerals: W. Arthur White. 1949. (Reprint from American Mineralogist, vol. 34, nos. 7 and 8, pp. 508-512, 1949.) 5 pp.
145. Niagaran Reefs in Illinois and Their Relation to Oil Accumulation: H. A. Lowenstam. 1949. 36 pp., 9 figs., 1 pl.
146. Application of Mineralogy to Soil Mechanics: (1) Some Fundamental Factors Influencing the Properties of Soil Materials. (2) The Composition in Relation to the Properties of Certain Soils: Ralph E. Grim. 1950. (Reprinted from Proceedings of the Second International Conference on Soil Mechanics and Foundation Engineering, vol. 3, Rotterdam, 1948, and from Geotechnique, vol. 1, no. 3, the Geotechnical Soc., London, June, 1949.) 21 pp., 12 figs.
147. Illinois Mineral Industry in 1948: Walter H. Voskuil. 1950. 73 pp., 16 figs.

Illinois Petroleum Series

59. Developments in Illinois and Indiana in 1948: A. H. Bell, R. E. Esarey, and B. E. Brooks. 1949. (Reprinted from Bull. Am. Assoc. Petr. Geol., vol. 33, no. 6, pp. 866-876, June 1949.) 11 pp.
60. Oil and Gas Development in Illinois in 1948: A. H. Bell, R. E. Esarey, and B. E. Brooks. 1949. (Reprint from Trans. A.I.M.E.)

Circulars

149. Where to Find Information on Mineral Raw Materials: M. M. Leighton. 1950. (Reprinted with additions from Chemical Industries, vol. 64, no. 6, pp. 930-931, 1949.) 8 pp., 3 figs.
151. Coal Resources of Franklin County, Illinois: G. H. Cady. Oil Accumulation in the Cypress Sandstone in the Herald Pool, White and Gallatin Counties, Illinois: Nancy McDurmitt. 1949. (Reprint from Transactions of the Illinois State Academy of Science, vol. 41, pp. 65-84, 1948.) 20 pp., 10 figs.
152. Southern Illinois: Mineral Resources and Industries: M. M. Leighton and W. H. Voskuil. 1949. (Reprint from *Southern Illinois*, University of Illinois Press, pp. 82-113, 1949.) 32 pp., 22 figs.
153. Flooding with Re-Used Water: Frederick Squires. 1949. (Reprint from World Oil, pp. 152-154, April 1949.) 4 pp., 2 figs.

154. Illinois Fluid Injection Research Reviewed: Frederick Squires. 1949. (Reprint from Producers Monthly, vol. 13, no. 9, pp. 32-43, 1949.) 12 pp.

155. Measuring Oil Reserves by Injected Gas: Frederick Squires. 1949. (Reprint from World Oil, pp. 170, 174, 175, September 1949.) 3 pp.

156. Acid Etching in the Study of Limestones and Dolomites: J. E. Lamar. 1950. 47 pp., 22 figs.

157. Short Papers on Geologic Subjects: Robert M. Grogan, Robert D. Knodle, Heinz A. Lowenstam, and Raymond S. Shrode. 1950. (Reprint from Trans. of Illinois State Academy of Science, vol. 42, pp. 97-119, December 1949.) 23 pp.

158. Structures Due to Volume Shrinkage in the Bedding Replacement Fluorspar Deposits of Southern Illinois: Robert M. Grogan. 1949. (Reprint from Econ. Geol., vol. 44, pp. 606-616, November 1949.) 11 pp.

159. Summary of Research Results on the Geologic Aspects of Radio Wave Transmission: M. W. Pullen. 1950. 7 pp., 3 figs.

160. Summary of Stratigraphy Shown in Geologic Cross-Section of Illinois Basin: L. E. Workman, D. H. Swann, and Elwood Atherton. 1950. 18 pp., 1 pl.

The Geological Survey's Applied Research Laboratory where semi-plant scale experiments work toward improved products from Illinois mineral resources.

161. Secondary Recovery in Illinois: Frederick Squires, Paul G. Luckhardt, and A. H. Bell. 1950. (Reprinted from Secondary Recovery of Oil in the United States, 2nd ed., 1950, pp. 505-521.) 17 pp., 6 figs.

162. Olmsted Fuller's Earth as a Bonding Clay for Foundry Use. Ralph E. Grim. 1950. 5 pp.

163. Flooding Prospects of Illinois Basin Oil sands: Frederick Squires and Paul G. Luckhardt. 1950. (Reprinted from World Oil, pp. 146-148, 150, 152, 154, March 1950.) 6 pp., 9 figs.

71. Second Printing. Structure of Herrin (No. 6) Coal Bed in Madison County: J. N. Payne. 1941.

150. Second Printing. Prospects for Oil Discoveries in Illinois Beyond Proven Areas and from Deeper Horizons: A. H. Bell and M. M. Leighton. 1949.

iscellaneous

Revised List of Publications. 1949.
Oil and Gas Drilling Reports, mimeographed, issued monthly.

BOARD OF NATURAL RESOURCES AND CONSERVATION

Honorable Noble J. Puffer, Chairman

Ex Officio Member—George D. Stoddard, President of the University of Illinois

Biology—A. E. Emerson, University of Chicago

Chemistry—Roger Adams, University of Illinois

Engineering—Louis R. Howson, Chicago

Forestry—Lewis H. Tiffany, Northwestern University, Vice President and Secretary of the Board

Geology—W. H. Newhouse, University of Chicago

The Geological Survey, the Natural History Survey, and the Water Survey are under the direction and control of The State Board of Natural Resources and Conservation. This board, created by the Civil Administrative Code in 1917, is composed of distinguished scientists, each qualified by at least ten years professional experience in his special field, and functions under the ex-officio chairmanship of the Director of the State Department of Registration and Education.

Under the law this Board selects and appoints, without reference to the State Civil Service law, all members of the technical staffs of the three scientific surveys. Traditionally nonpartisan, its members serve without pay. Membership is by appointment of the Governor, and it is a standing tribute to the broad vision of our State administration and to the abilities of the Board members that since the Board's inception, changes on the Board have been made only by the death or retirement of a member. Because several sciences, three different universities, and industry are represented by the Board membership, its points of view are broad and in the interest of the people of the entire State.

The Board, which meets at regular intervals, receives and carefully studies quarterly reports from the three chiefs of the Scientific Surveys. Members of the Board frequently make field inspections of projects with which they are most intimately concerned.

By their wise guidance of the individual Surveys and their coordination of the activities of these three organizations, members of the Board have through the years made valuable contributions to the development, intelligent utilization, and conservation of the State's natural resources. Their devotion to the responsibilities imposed upon them by law, their recognition of measures consistent with sound public policy, their comprehension of fruitful research programs, and their exercise of infinite care in selection of scientific staffs have brought national and international recognition of Illinois and its wealth of natural resources.

Although the three Scientific Surveys are administered by the State Department of Registration and Education, location of the Survey's headquarters and principal laboratories on the University of Illinois campus at Urbana offers many advantages. Research is furthered through

the availability of the University libraries and some of the laboratories and experimental field-plots, and in like manner Survey facilities are made available to University staff members and some advanced students seeking professional training. Cordial relations and a generous exchange of information between University and Survey staffs make for prompt and effective dissemination of the results of research. Operational economy is also achieved by one system, maintained by the University, that provides water, heat, light and other services for the Surveys and the University.